

Biobased Industrial Products—

Not a New Idea for ARS

During World War II, with rubber in critically short supply, ARS scientists rose to the country's need for tires and other products by developing a superior synthetic rubber.

Synthetic rubber had been of very poor quality. But ARS scientists at the Naval Stores Laboratory of the Southern Regional Research Center remarkably improved synthetic rubber's quality when they devised a biobased substitute for the compound that initiates the reaction process. In place of a petroleum-based chemical, the researchers came up with an initiator from citrus peels and pine tar.

Industry adopted the new process and used it to make over 1 million tons of synthetic rubber annually for many years. But it was also just another milestone in a long line of agricultural research accomplishments for ARS.

A Mission of Innovation

"Biobased industrial product research"—these are some of today's hottest topics. But ARS isn't some Johnny-come-lately, suddenly jumping on the biobased bandwagon. From the agency's earliest days, ARS has made developing new industrial products from agricultural crops an essential part of its mission. Epoxy resins from sugar, packing-peanuts from cornstarch, 100-percent soybean printing ink, and industrial lubricants from meadowfoam and other oilseeds are all as much a part of ARS as new tomato varieties and better irrigation systems.

Sometimes ARS' biobased product research has been about replacing a petroleum source, such as with the synthetic rubber. Other times, the agency's research has created the basis for whole new industries—for completely new products.

A good example is the invention of Super Slurper, a chemical marriage between cornstarch and a synthetic compound, which can absorb nearly

BRIAN PRECHTEL (K7854-1)



Close-up of meadowfoam.

BRIAN PRECHTEL (K7856-1)

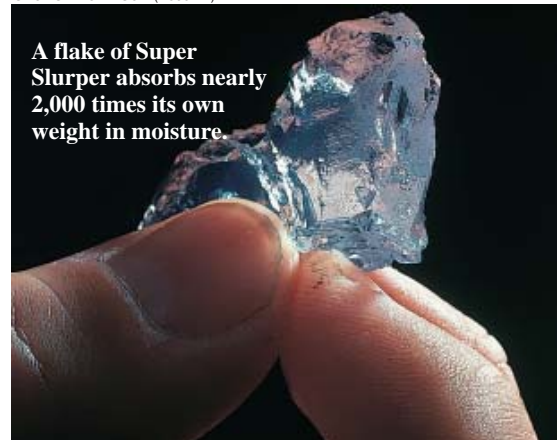


Meadowfoam in full bloom.

2,000 times its own weight in moisture. Super Slurper is used in batteries, fuel filters, baby powders, wound dressings, soil conditioners, and seed coatings. Compounds very much like it are also used in disposable diapers and sanitary napkins.

"Until ARS showed the world this chemical cross-linking was possible, there were no superabsorbents. The closest thing anyone had before Super Slurper absorbed only 27 times its weight, and it was expensive and hard to make," says

GEORGE ROBINSON (K839-14)



A flake of Super Slurper absorbs nearly 2,000 times its own weight in moisture.



Ed Kirkland, president of Super Absorbents Company, Inc., in Lumberton, North Carolina.

Super Absorbents Company continues to use the original ARS formula for Super Slurper to make seed coatings and soil conditioners and to sell to companies that repackage the product as an aqueous absorbent in chemical spill control.

Kirkland has seen as much as a 33-percent increase in soybean germination with a seed coating of Super Slurper. He also found that 3 to 4 pounds of Super

Slurper per acre excites soil microbes, which improves plant vitality, especially for legumes like soybeans.

While Kirkland readily grants ARS the credit for kicking off today's \$2-billion-a-year superabsorbent industry, most no longer remember the agency's seminal work. These days, Super Slurper has been superseded by new and synthetic superabsorbents, which have evolved far past the original 1977 patents that came out of ARS' National Center for Agricultural Utilization Research (NCAUR) in Peoria, Illinois.

"What most of the industry is using now is the great grandson of Super Slurper, and a lot of it is completely synthetic rather than starch based now that the chemistry is understood," explains ARS chemical engineer J.L. Willett in NCAUR's Plant Polymer Research Unit. "Research is always a cycle. Anything you do, others will take further, and new products and processes will evolve and replace the old ones. But someone has to do the high-risk and basic research so the first steps get taken."

And the cycle continues. NCAUR scientists intend to revisit the starch-based superabsorbent concept in the coming year. "We want to see whether we can redesign the biobased process to make it more effective and cost competitive with the current synthetics," Willett says.

Win-Win Propositions

Any time a renewable resource can be tapped to produce a product that is as effective and economically competitive as the synthetic, everyone gains. Farmers benefit from new markets; the environment benefits from biodegradable or renewable-sourced products; the country becomes less dependent on imported petroleum; and consumers get new, useful goods.

Take packing peanuts, for example. Everyone wonders what to do with those ubiquitous pieces of polystyrene that last forever. In the 1970s, ARS scientists at NCAUR developed a material made

KEITH WELLER (K7203-15)



Biodegradable packing peanuts are 95 percent starch, 5 percent synthetic polymer.

from starch that could be used to make biodegradable packing peanuts and similar products. But getting it to market has been a long road.

It often takes 15 to 20 years for a new material to be accepted and adopted by industry.

Today, Uni-Star Industries, Ltd., in Marion, Arkansas, makes starch-based resins that end up as 2 million cubic feet of biodegradable loose fill each year. They use a starch-grafting process that has its roots directly in the ARS-developed technology.

"If you put a packing peanut from our material under a faucet or drop it in a glass of water, it will just dissolve away," explains Don Fisk, director of technology for Uni-Star Industries.

"But that 2 million cubic feet made from our materials is only about 10 percent of the packing-peanut market. Achieving market acceptance from

manufacturers used to a different raw material is not easy," he adds. "Manufacturers have an investment in machinery that handles the existing material well. Why should they change?"

To entice acceptance, it has been essential to make starch-based "polystyrene" not only workable, but also economically competitive with synthetics, regardless of its environmental benefits. Fisk continues to improve the production process, and he expects to gain more market share as costs decrease and his product line expands.

Feathering New Nests

To help speed industry's adoption of a new biobased technology, ARS scientists' work doesn't stop with publishing results. Along with the agency's Office of Technology Transfer, they can actively reach out to interest businesses and entrepreneurs in the commercial potential of the research. Once an agreement or patent license is signed between ARS and a company, the agency's researchers often continue to help solve the host of complications that occur between an initial pilot-plant design and production of viable commercial end-products.

For example, ARS chemist Walter Schmidt with the Environmental Quality Laboratory in Beltsville, Maryland, developed and patented a process that converts chicken feathers—a low-value waste product of the poultry industry—to a source of high-value fibers. Strong as nylon and finer than wood pulp, these fibers have potential as a renewable, recyclable resource to manufacture everything from insulation to municipal water filters, from stationery to car dashboards. They may even be able to clean up radioactive waste.

Schmidt has put in many hours discussing the potential for feathers as industrial products or components of products with prospective commercializers. "Twelve different companies expressed interest in the patent," Schmidt says.

Since 1998, when Tyson Foods, Inc., Springdale, Arkansas; Maxim, LLC, Pasadena, California; and Featherfiber Corp., Nixa, Missouri, licensed the technology, Schmidt has helped the three companies figure out how to scale up the lab process to a pilot-plant level of commercial production. At the same time, he's been helping to build market credibility for a new industrial biobased resource.

Explains Maxim's company president and CEO Carlo Licata, "We could not

feather fiber's unusually high potential as an absorbent of heavy metals. He is planning to market feather fiber in three major areas. The first is as a filter for municipal water, capable of removing even nanosized particles. "It can even remove chromium 6 from drinking water," he says.

The second is as an industrial absorbent of heavy metals in soil and water. "And even better, I can release the heavy metals from the fibers afterwards, so the metals can be recycled," he says.

Third, Licata has discovered that feather fiber has a great affinity for absorbing radioactive strontium and cesium. "We are ready to try a demonstration project to show that feather fiber can clean up hot—radioactive—material," Licata says.

Feather fiber has incredible product potential as a renewable source, "provided we can create a market for it," he adds.

One day, feather fiber may be as big an industry as another ARS success story—flexible polyvinyl chloride (PVC). In the late 1940s, vinyl plastics were unstable in sunlight, quickly became brittle, and required the use of poisonous stabilizers. But researchers at the ARS Eastern Regional Research Center in Wyndmoor, Pennsylvania, discovered that by inserting an atom of oxygen into unsaturated fatty acids, they created stable, flexible vinyl. Today, roughly 50,000 tons a year of flexible PVC go into miles of hoses, floor coverings, even plastic tablecloths, still based on the original ARS chemistry.—
By J. Kim Kaplan, ARS.

This research is part of Quality and Utilization of Agricultural Products, an ARS National Program (#306) described on the World Wide Web at <http://www.nps.ars.usda.gov>.

To reach people mentioned in this article, contact J. Kim Kaplan, USDA-ARS Information Staff, 5601 Sunnyside Ave., Beltsville, MD 20705-5128; phone (301) 504-1637, fax (301) 504-1648, e-mail kaplan@ars.usda.gov. ♦

KEITH WELLER (K3998-5)



Chemist Sevim Erhan prepares 100-percent soybean oil inks for laboratory printing tests.

have gotten off the ground without ARS' research. But more than that, ongoing guidance from Walter Schmidt has been a major asset in making feather fiber work. Walter has kept it from becoming so frustrating that I gave up on feather fiber. Starting an industry like this isn't an easy task."

Licata is currently concentrating on